

CLAIMS

1 1. A computer implemented method for in-place
2 preservation of file system objects during a clone
3 operation, the method comprising the steps of:
4 a cloning manager determining boundaries of a
5 file system to be created by the clone
6 operation;
7 the cloning manager identifying at least one
8 protected area within the boundaries
9 reserved for the file system to be created
10 by the clone operation;
11 the cloning manager identifying at least one in-
12 place file system object at least partially
13 within the boundaries to be preserved during
14 the clone operation;
15 the cloning manager storing, in a location that
16 will not be affected by the clone operation,
17 metadata concerning each in-place file
18 system object at least partially within the
19 boundaries to be preserved during the clone
20 operation;
21 the cloning manager ensuring that each in-place
22 file system object at least partially within

23 the boundaries to be preserved during the
24 clone operation is not located in a
25 protected area; and
26 the cloning manager creating the file system
27 during the clone operation only in locations
28 within the boundaries in which no in-place
29 file system object to be preserved is
30 located.

1 2. The method of claim 1 wherein the cloning manager
2 determining the boundaries of a file system to be created
3 by the clone operation comprises:
4 the cloning manager analyzing data concerning the
5 clone operation to determine at least one
6 attribute concerning the file system to be
7 created from a group of attributes
8 consisting of:
9 a file system type of the file system to be
10 created;
11 a location of volume boundaries of the file
12 system to be created;
13 storage geometry concerning the file system
14 to be created; and

15 a number of total sectors to be used by the
16 file system to be created.

1 3. The method of claim 1 wherein the cloning manager
2 identifying at least one protected area within the
3 boundaries reserved for the file system to be created by
4 the clone operation comprises the cloning manager
5 performing at least one step from a group of steps
6 consisting of:

7 identifying at least one protected area required
8 by the file system to be created by the
9 clone operation; and

10 identifying at least one protected area not
11 required by but optimally reserved for the
12 file system to be created by the clone
13 operation.

1 4. The method of claim 1 wherein the cloning manager
2 identifying at least one in-place file system object with
3 the boundaries to be preserved during the clone operation
4 comprises:

5 the cloning manager compiling a list of in-place
6 file system objects to be preserved during
7 the clone operation; and

8 the cloning manager eliminating any in-place file
9 system objects which will not be affected by
10 the clone operation from the list.

1 5. The method of claim 4 wherein the cloning manager
2 eliminating any in-place file system objects which will not
3 be affected by the clone operation from the list further
4 comprises:

5 the cloning manager identifying at least one file
6 system object to be preserved which is not
7 located on the physical medium on which the
8 file system is to be created by the clone
9 operation; and

10 the cloning manager eliminating each identified
11 file system object which is not located on
12 the physical medium from the list.

1 6. The method of claim 4 wherein the cloning manager
2 eliminating any in-place file system objects which will not
3 be affected by the clone operation from the list further
4 comprises:

5 the cloning manager identifying at least one file
6 system object to be preserved which is
7 located outside of the boundaries of the

8 file system to be created by the clone
9 operation; and
10 the cloning manager eliminating each identified
11 file system object which is located outside
12 of the boundaries from the list.

1 7. The method of claim 1 wherein the cloning manager
2 storing metadata concerning each in-place file system
3 object to be preserved during the clone operation further
4 comprises:

5 the cloning manager storing, for each in-place
6 system object to be preserved during the
7 clone operation, at least one metadatum
8 concerning the file system object from a
9 group of metadata consisting of:
10 a path of the file system object;
11 at least one attribute concerning the file
12 system object; and
13 a logical location of the file system
14 object;
15 a physical storage location of content of
16 the file system object.

1 8. The method of claim 1 wherein the cloning manager
2 storing metadata concerning each in-place file system

3 object to be preserved during the clone operation further
4 comprises:

5 the cloning manager storing the metadata in a
6 location that will not be affected by the
7 clone operation in a format from a group of
8 formats consisting of:
9 at least two files, each file containing the
10 metadata so as to support fault
11 tolerance;
12 at least one record in a database supporting
13 fault tolerance;
14 a single file; and
15 structured data in random access memory.

1 9. The method of claim 1 wherein the cloning manager
2 ensuring that each in-place file system object at least
3 partially within the boundaries to be preserved during the
4 clone operation is not located in a protected area
5 comprises:

6 the cloning manager comparing a location of each
7 file system object at least partially within
8 the boundaries to be preserved during the
9 clone operation to locations of identified

10 protected areas reserved for the file system
11 to be created by the clone operation; and
12 responsive to the cloning manager determining
13 that a location of a file system object
14 conflicts with a location of a protected
15 area, the cloning manager performing a step
16 from a group of steps consisting of:
17 moving the conflicting file system object to
18 an available non-conflicting location,
19 and updating metadata concerning the
20 file system object accordingly; and
21 classifying the result of the determination
22 as an error condition.

1 10. The method of claim 1 wherein the cloning manager
2 creating the file system during the clone operation only in
3 locations within the boundaries in which no in-place file
4 system object to be preserved is located comprises:
5 before allocating at least one sector for the
6 creation of the file system, the cloning
7 manager checking the stored metadata
8 concerning the in-place file system objects
9 to determine if at least one file system

10 object to be preserved is located at that
11 location; and
12 responsive to determining that at least one file
13 system object to be preserved is located at
14 that location, allocating the at least one
15 sector to the file system at an available
16 non-conflicting location.

1 11. The method of claim 1 wherein:
2 the cloning manager identifying at least one in-
3 place file system object at least partially
4 within the boundaries to be preserved during
5 the clone operation further comprises the
6 cloning manager identifying at least one in-
7 place file system object to be both
8 preserved during the clone operation and
9 incorporated into the file system created by
10 the clone operation; and
11 wherein the cloning manager storing, in a
12 location that will not be affected by the
13 clone operation, metadata concerning each
14 in-place file system object further
15 comprises the cloning manager storing
16 metadata concerning each identified file

17 system object to be both preserved during
18 the clone operation and incorporated into
19 the file system created by the clone
20 operation, the metadata comprising at least
21 one metadatum from a group of metadata
22 consisting of:
23 an indication that the file system object is
24 to be incorporated in the file system
25 to be created by the clone operation;
26 a recovery path of the file system object
27 within the file system to be created by
28 the clone operation; and
29 a recovery partition of the file system
30 object within the file system to be
31 created by the clone operation.

1 12. The method of claim 11 further comprising:
2 the cloning manager determining that at least one
3 identified in-place file system object to be
4 incorporated into the file system to be
5 created by the clone operation is not
6 compatible with the file system to be
7 created by the clone operation; and

8 responsive to the determination, the cloning
9 manager performing a step from a group of
10 steps consisting of:
11 modifying at least one identified file
12 system object to be compatible with the
13 file system to be created by the clone
14 operation; and
15 classifying the identification as an error
16 condition.

1 13. The method of claim 11 further comprising:
2 for each identified in-place file system object
3 to be incorporated into the file system, the
4 cloning manager determining whether its
5 content is located within a location that is
6 to be a data area of the file system, and
7 whether its location is properly aligned
8 according to storage geometry of the file
9 system; and
10 responsive to determining that the location of at
11 least one in-place file system object to be
12 incorporated into the file system is not
13 compatible with the file system, the cloning

14 manager performing a step from a group of
15 steps consisting of:
16 moving the in-place file system object such
17 that its new location is compatible
18 with the file system and updating the
19 associated metadata accordingly; and
20 classifying the result of the determination
21 as an error condition.

1 14. The method of claim 11 further comprising the
2 cloning manager performing the following additional steps
3 after the clone operation:
4 using appropriate stored metadata to create a
5 directory entry in the created file system
6 for each identified file system object to be
7 incorporated into the created file system;
8 and
9 updating metadata concerning the created file
10 system to map the content location of each
11 identified file system object into the
12 created file system.

1 15. The method of claim 1 further comprising:
2 the cloning manager determining whether target
3 storage medium is of sufficient size to

4 store each identified in-place file system
5 object to be preserved during the clone
6 operation and the file system to be created
7 by the clone operation;
8 responsive to the result of the determining step,
9 the cloning manager performing a step from a
10 group of steps consisting of:
11 responsive to determining that the target
12 storage medium is of sufficient size,
13 proceeding with the clone operation;
14 and
15 responsive to determining that the target storage
16 medium is not of sufficient size,
17 classifying the result of the determination
18 as an error condition.

1 16. The method of claim 1 further comprising:

2 the cloning manager creating at least two file
3 systems during the clone operation.

17. The method of claim 1 further comprising:

5 the cloning manager creating at least one file system
during the clone operation on at least two storage media.

1 18. A computer readable medium containing a computer
2 program product for in-place preservation of file system
3 objects during a clone operation, the computer program
4 product comprising:
5 program code for determining boundaries of a file
6 system to be created by the clone operation;
7 program code for identifying at least one
8 protected area within the boundaries
9 reserved for the file system to be created
10 by the clone operation;
11 program code for identifying at least one in-
12 place file system object at least partially
13 within the boundaries to be preserved during
14 the clone operation;
15 program code for storing, in a location that will
16 not be affected by the clone operation,
17 metadata concerning each in-place file
18 system object at least partially within the
19 boundaries to be preserved during the clone
20 operation;
21 program code for ensuring that each in-place file
22 system object at least partially within the
23 boundaries to be preserved during the clone

24 operation is not located in a protected
25 area; and
26 program code for creating the file system during
27 the clone operation only in locations within
28 the boundaries in which no in-place file
29 system object to be preserved is located.

1 19. The computer program product of 18 wherein the
2 program code for determining the boundaries of a file
3 system to be created by the clone operation comprises:
4 program code for analyzing data concerning the
5 clone operation to determine at least one
6 attribute concerning the file system to be
7 created from a group of attributes
8 consisting of:
9 a file system type of the file system to be
10 created;
11 a location of volume boundaries of the file
12 system to be created;
13 storage geometry concerning the file system
14 to be created; and
15 a number of total sectors to be used by the
16 file system to be created.

1 20. The computer program product of claim 18 wherein
2 the program code for identifying at least one protected
3 area within the boundaries reserved for the file system to
4 be created by the clone operation further comprises at
5 least one program code from a group of program codes
6 consisting of:

7 program code for identifying at least one
8 protected area required by the file system
9 to be created by the clone operation; and
10 program code for identifying at least one
11 protected area not required by but optimally
12 reserved for the file system to be created
13 by the clone operation.

1 21. The computer program product of claim 18 wherein
2 the program code for storing metadata concerning each in-
3 place file system object to be preserved during the clone
4 operation further comprises:

5 program code for storing, for each in-place
6 system object to be preserved during the
7 clone operation, at least one metadatum
8 concerning the file system object from a
9 group of metadata consisting of:
10 a path of the file system object;

11 at least one attribute concerning the file
12 system object; and
13 a logical location of the file system
14 object;
15 a physical storage location of content of
16 the file system object.

1 22. The computer program product of claim 18 wherein
2 the program code for storing metadata concerning each in-
3 place file system object to be preserved during the clone
4 operation further comprises:
5 program code for storing the metadata in a
6 location that will not be affected by the
7 clone operation in a format from a group of
8 formats consisting of:
9 at least two files, each file containing the
10 metadata so as to support fault
11 tolerance;
12 at least one record in a database supporting
13 fault tolerance;
14 a single file; and
15 structured data in random access memory.

1 23. The computer program product of claim 18 wherein
2 the program code for ensuring that each in-place file

3 system object at least partially within the boundaries to
4 be preserved during the clone operation is not located in a
5 protected area comprises:

6 program code for comparing a location of each
7 file system object at least partially within
8 the boundaries to be preserved during the
9 clone operation to locations of identified
10 protected areas reserved for the file system
11 to be created by the clone operation; and

12 at least one program code for from a group of
13 program codes consisting of:

14 program code for, responsive to determining
15 that a location of a file system object
16 conflicts with a location of a
17 protected area, moving the conflicting
18 file system object to an available non-
19 conflicting location, and updating
20 metadata concerning the file system
21 object accordingly; and

22 program code for, responsive to determining
23 that a location of a file system object
24 conflicts with a location of a
25 protected area, classifying the result

26 of the determination as an error
27 condition.

1 24. The computer program product of claim 18 wherein
2 the program code for creating the file system during the
3 clone operation only in locations within the boundaries in
4 which no in-place file system object to be preserved is
5 located comprises:

6 program code for, before allocating at least one
7 sector for the creation of the file system,
8 checking the stored metadata concerning the
9 in-place file system objects to determine if
10 at least one file system object to be
11 preserved is located at that location; and
12 program code for, responsive to determining that
13 at least one file system object to be
14 preserved is located at that location,
15 allocating the at least one sector to the
16 file system at an available non-conflicting
17 location.

1 25. The computer program product of claim 18 wherein:
2 the program code for identifying at least one in-
3 place file system object at least partially
4 within the boundaries to be preserved during

5 the clone operation further comprises
6 program code for identifying at least one
7 in-place file system object to be both
8 preserved during the clone operation and
9 incorporated into the file system created by
10 the clone operation; and
11 wherein the program code for storing, in a
12 location that will not be affected by the
13 clone operation, metadata concerning each
14 in-place file system object further
15 comprises program code for storing metadata
16 concerning each identified file system
17 object to be both preserved during the clone
18 operation and incorporated into the file
19 system created by the clone operation, the
20 metadata comprising at least one metadatum
21 from a group of metadata consisting of:
22 an indication that the file system object is
23 to be incorporated in the file system
24 to be created by the clone operation;
25 a recovery path of the file system object
26 within the file system to be created by
27 the clone operation; and

28 a recovery partition of the file system
29 object within the file system to be
30 created by the clone operation.

1 26. The computer program product of claim 25 further
2 comprising:
3 program code for determining, for each identified
4 in-place file system object to be
5 incorporated into the file system, whether
6 its content is located within a location
7 that is to be a data area of the file
8 system, and whether its location is properly
9 aligned according to storage geometry of the
10 file system; and
11 at least one program code from a group of program
12 codes consisting of:
13 program code for, responsive to determining
14 that the location of at least one in-
15 place file system object to be
16 incorporated into the file system is
17 not compatible with the file system,
18 moving the in-place file system object
19 such that its new location is
20 compatible with the file system and

21 updating the associated metadata
22 accordingly; and
23 program code for, responsive to determining
24 that the location of at least one in-
25 place file system object to be
26 incorporated into the file system is
27 not compatible with the file system,
28 classifying the result of the
29 determination as an error condition.

1 27. The computer program product of claim 25 further
2 comprising:
3 program code for using appropriate stored
4 metadata to create a directory entry in the
5 created file system for each identified file
6 system object to be incorporated into the
7 created file system; and
8 program code for updating metadata concerning the
9 created file system to map the content
10 location of each identified file system
11 object into the created file system.

1 28. A computer system for in-place preservation of
2 file system objects during a clone operation, the computer
3 system comprising:

4 a software portion configured to determine
5 boundaries of a file system to be created by
6 the clone operation;
7 a software portion configured to identify at
8 least one protected area within the
9 boundaries reserved for the file system to
10 be created by the clone operation;
11 a software portion configured to identify at
12 least one in-place file system object at
13 least partially within the boundaries to be
14 preserved during the clone operation;
15 a software portion configured to store, in a
16 location that will not be affected by the
17 clone operation, metadata concerning each
18 in-place file system object at least
19 partially within the boundaries to be
20 preserved during the clone operation;
21 a software portion configured to ensure that each
22 in-place file system object at least
23 partially within the boundaries to be
24 preserved during the clone operation is not
25 located in a protected area; and
26 a software portion configured to create the file
27 system during the clone operation only in

28 locations within the boundaries in which no
29 in-place file system object to be preserved
30 is located.

1 29. The computer system of 28 wherein the software
2 portion configured to determine the boundaries of a file
3 system to be created by the clone operation comprises:
4 a software portion configured to analyze data
5 concerning the clone operation to determine
6 at least one attribute concerning the file
7 system to be created from a group of
8 attributes consisting of:
9 a file system type of the file system to be
10 created;
11 a location of volume boundaries of the file
12 system to be created;
13 storage geometry concerning the file system
14 to be created; and
15 a number of total sectors to be used by the
16 file system to be created.

1 30. The computer system of claim 28 wherein the
2 software portion configured to identify at least one
3 protected area within the boundaries reserved for the file
4 system to be created by the clone operation further

5 comprises at least one software portion from group of
6 software portions consisting of:
7 a software portion configured to identify at
8 least one protected area required by the
9 file system to be created by the clone
10 operation; and
11 a software portion configured to identify at
12 least one protected area not required by but
13 optimally reserved for the file system to be
14 created by the clone operation.

1 31. The computer system of claim 28 wherein the
2 software portion configured to store metadata concerning
3 each in-place file system object to be preserved during the
4 clone operation further comprises:

5 a software portion configured to store, for each
6 in-place system object to be preserved
7 during the clone operation, at least one
8 metadatum concerning the file system object
9 from a group of metadata consisting of:
10 a path of the file system object;
11 at least one attribute concerning the file
12 system object; and

13 a logical location of the file system
14 object;
15 a physical storage location of content of
16 the file system object.

1 32. The computer system of claim 28 wherein the
2 software portion configured to store metadata concerning
3 each in-place file system object to be preserved during the
4 clone operation further comprises:

5 a software portion configured to store the
6 metadata in a location that will not be
7 affected by the clone operation in a format
8 from a group of formats consisting of:
9 at least two files, each file containing the
10 metadata so as to support fault
11 tolerance;
12 at least one record in a database supporting
13 fault tolerance;
14 a single file; and
15 structured data in random access memory.

1 33. The computer system of claim 28 wherein the
2 software portion configured to ensure that each in-place
3 file system object at least partially within the boundaries

4 to be preserved during the clone operation is not located
5 in a protected area comprises:

6 a software portion configured to compare a
7 location of each file system object at least
8 partially within the boundaries to be
9 preserved during the clone operation to
10 locations of identified protected areas
11 reserved for the file system to be created
12 by the clone operation; and

13 at least one software portion from a group of
14 software portions consisting of:

15 a software portion configured to move,
16 responsive to determining that a
17 location of a file system object
18 conflicts with a location of a
19 protected area, the conflicting file
20 system object to an available non-
21 conflicting location, and to update
22 metadata concerning the file system
23 object accordingly; and

24 a software portion configured to classify,
25 responsive to determining that a
26 location of a file system object
27 conflicts with a location of a

28 protected area, the result of the
29 determination as an error condition.

1 34. The computer system of claim 28 wherein the
2 software portion configured to create the file system
3 during the clone operation only in locations within the
4 boundaries in which no in-place file system object to be
5 preserved is located comprises:
6 a software portion configured to check, before
7 allocating at least one sector for the
8 creation of the file system, the stored
9 metadata concerning the in-place file system
10 objects to determine if at least one file
11 system object to be preserved is located at
12 that location; and
13 a software portion configured to allocate,
14 responsive to determining that at least one
15 file system object to be preserved is
16 located at that location, the at least one
17 sector to the file system at an available
18 non-conflicting location.

1 35. The computer system of claim 28 wherein:
2 the software portion configured to identify at
3 least one in-place file system object at

4 least partially within the boundaries to be
5 preserved during the clone operation further
6 comprises a software portion configured to
7 identify at least one in-place file system
8 object to be both preserved during the clone
9 operation and incorporated into the file
10 system created by the clone operation; and
11 wherein the software portion configured to store,
12 in a location that will not be affected by
13 the clone operation, metadata concerning
14 each in-place file system object further
15 comprises a software portion configured to
16 store metadata concerning each identified
17 file system object to be both preserved
18 during the clone operation and incorporated
19 into the file system created by the clone
20 operation, the metadata comprising at least
21 one metadatum from a group of metadata
22 consisting of:
23 an indication that the file system object is
24 to be incorporated in the file system
25 to be created by the clone operation;

26 a recovery path of the file system object
27 within the file system to be created by
28 the clone operation; and
29 a recovery partition of the file system
30 object within the file system to be
31 created by the clone operation.

1 36. The computer system of claim 35 further
2 comprising:

3 a software portion configured to determine, for
4 each identified in-place file system object
5 to be incorporated into the file system,
6 whether its content is located within a
7 location that is to be a data area of the
8 file system, and whether its location is
9 properly aligned according to storage
10 geometry of the file system; and

11 at least one software portion from a group of
12 software portions consisting of:

13 a software portion configured to move,
14 responsive to determining that the
15 location of at least one in-place file
16 system object to be incorporated into
17 the file system is not compatible with

18 the file system, the in-place file
19 system object such that its new
20 location is compatible with the file
21 system and updating the associated
22 metadata accordingly; and
23 a software portion configured to classify,
24 responsive to determining that the
25 location of at least one in-place file
26 system object to be incorporated into
27 the file system is not compatible with
28 the file system, the result of the
29 determination as an error condition.

1 37. The computer system of claim 35 further
2 comprising:
3 a software portion configured to use appropriate
4 stored metadata to create a directory entry
5 in the created file system for each
6 identified file system object to be
7 incorporated into the created file system;
8 and
9 a software portion configured to update metadata
10 concerning the created file system to map

11 the content location of each identified file
12 system object into the created file system.